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Detection of Moisture and Moisture Related Phenomena from Skylab

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Soil Moisture Distributions in the Test Sites

The soil moisture content of sample sites were obtained along the Skylab track for all missions for relating to the return of Skylab sensors. Although the distribution of samples in the test sites were carefully devised before going to the field, the coverage of sensors was so large that samples could not cover the entire area. Also all the soil samples could not be taken in the same day. In addition, thunderstorms in the summer are very localized. As a result, distribution of soil water content can vary considerably in short distances. Therefore, it has been found necessary to apply the techniques of climatic water balance calculations to improve the ground truth information on the geographical distribution of soil moisture in the test sites.

The climatic water balance technique required the calculation of potential and actual evapotranspiration from meteorological parameters. Thus, the soil moisture storage and runoff could be determined by these calculations for various soil types.

The methods used in this report were developed by Thornthwaite (1948), Thornthwaite and Mather (1955), and Eagleman (1971). These methods are simple to use and produce good results (Penman, 1956 and Lin and Eagleman, 1971). Thornthwaite's equation can estimate daily rate

of potential evapotranspiration (PE) from mean daily temperature. This PE rate is adjusted by a factor which varies with the day of year and the latitude of the station (Thornthwaite and Mather, 1957). The actual evapotranspiration at any location depends upon PE, precipitation and the availability of soil mositure and can be calculated (Eagleman, 1972). The available water which is the amount of water between wilting point and field capacity, varies with different soils, Table I (Salter and Williams, 1965). The soil type of each station was determined from county soil survey maps and other sources. A computer program (FORTRAN IV) has been developed for these calculations. The inputs of the program are monthly temperature, daily temperature, daily precipitation, soil type, initial value of soil moisture, and latitude of each station. The daily variation of soil water storage in the upper six inches of soil depth was then computed for 61 stations (Figure 1) from May 1 to September 13, 1973 in Texas and New Mexico, and for 57 stations (Figure 2) from July 19 to September 18, 1973 in Kansas.

In order to be of value for comparison with Skylab data, the moisture content of the upper six inch layer had to be partitioned into each of the separate one inch layers. This was accomplished by using the moisture profile from the sites where soil moisture measurements were

TABLE I

Available Water Data for the Top 12 in. of Soil Summarized as Means per Textural Class (After Salter and Williams, 1965).

Textural Class	FC (% H_2O)	WP (% H_2O)	AW (in.)
Sand	6.7	1.8	0.79
Loamy Sand	17.9	5.1	2.15
Fine Sandy Loam	25.6	9.5	2.56
Silt Loam	35.3	12.7	2.82
Clay	39.4	22.1	1.93

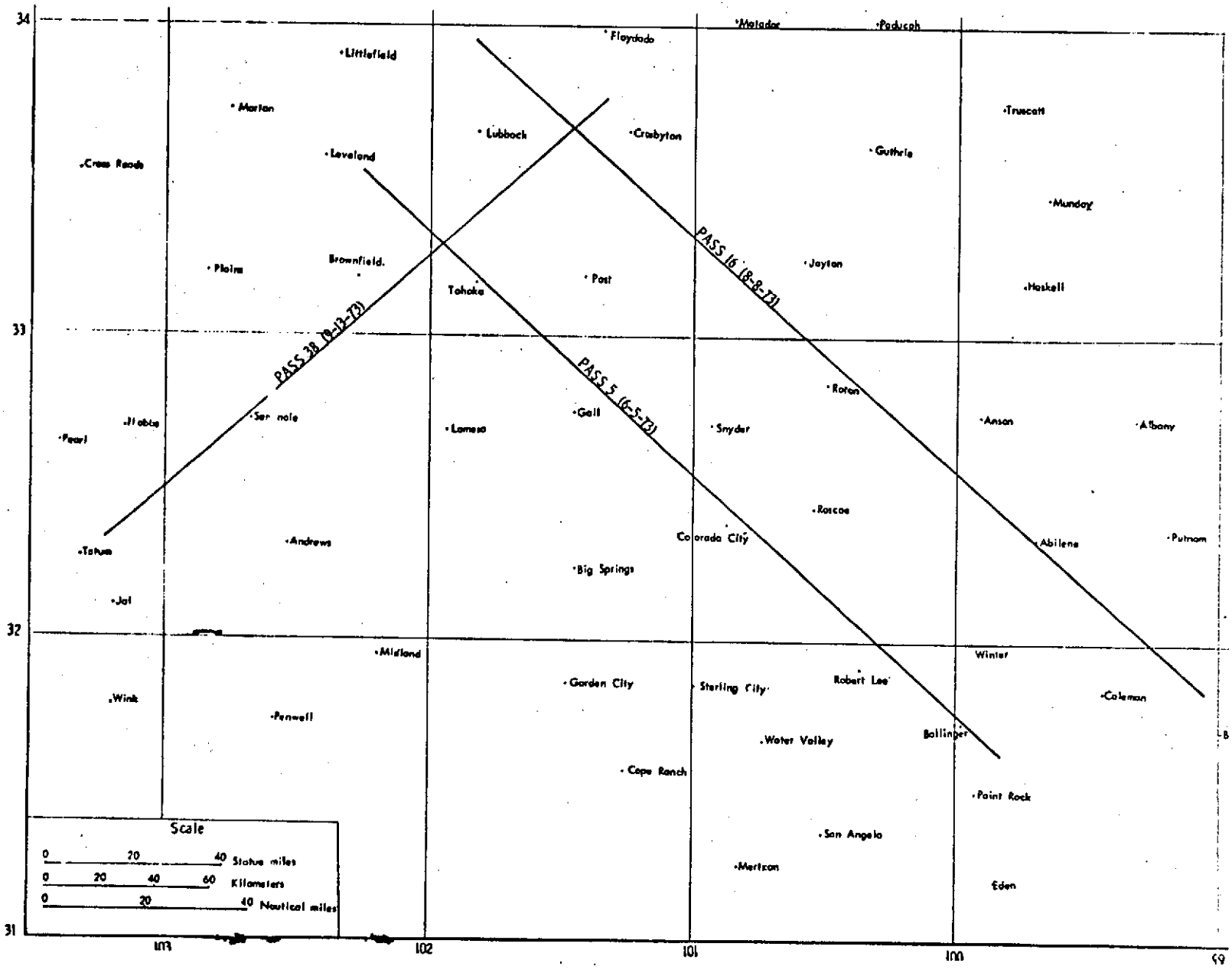

34
33
32
31
103
102
101
100
99
Matador
Paducah
Floydada
Littlefield
Morton
Lubbock
Crosbyton
Truscott
Cross Roads
Levelland
Guthrie
Mundoy
Plains
Brownfield
Tahoka
Post
Jayton
Haskell
PASS 38 (10-12-73)
PASS 16 (18-8-73)
PASS 5 (16-5-73)
Roton
Hobbs
Seminole
Gail
Lamesa
Snyder
Anson
Albany
Pearl
Roscoe
Andrews
Colorado City
Abilene
Putnam
Tatum
Big Springs
Jal
Midland
Winter
Garden City
Sterling City
Robert Lee
Coleman
Wink
Penwell
Water Valley
Ballinger
Cape Ranch
Point Rock
San Angelo
Mertzon
Eden
Scale
0 20 40 Statue miles
0 20 40 60 Kilometers
0 20 40 Nautical miles

Figure 1

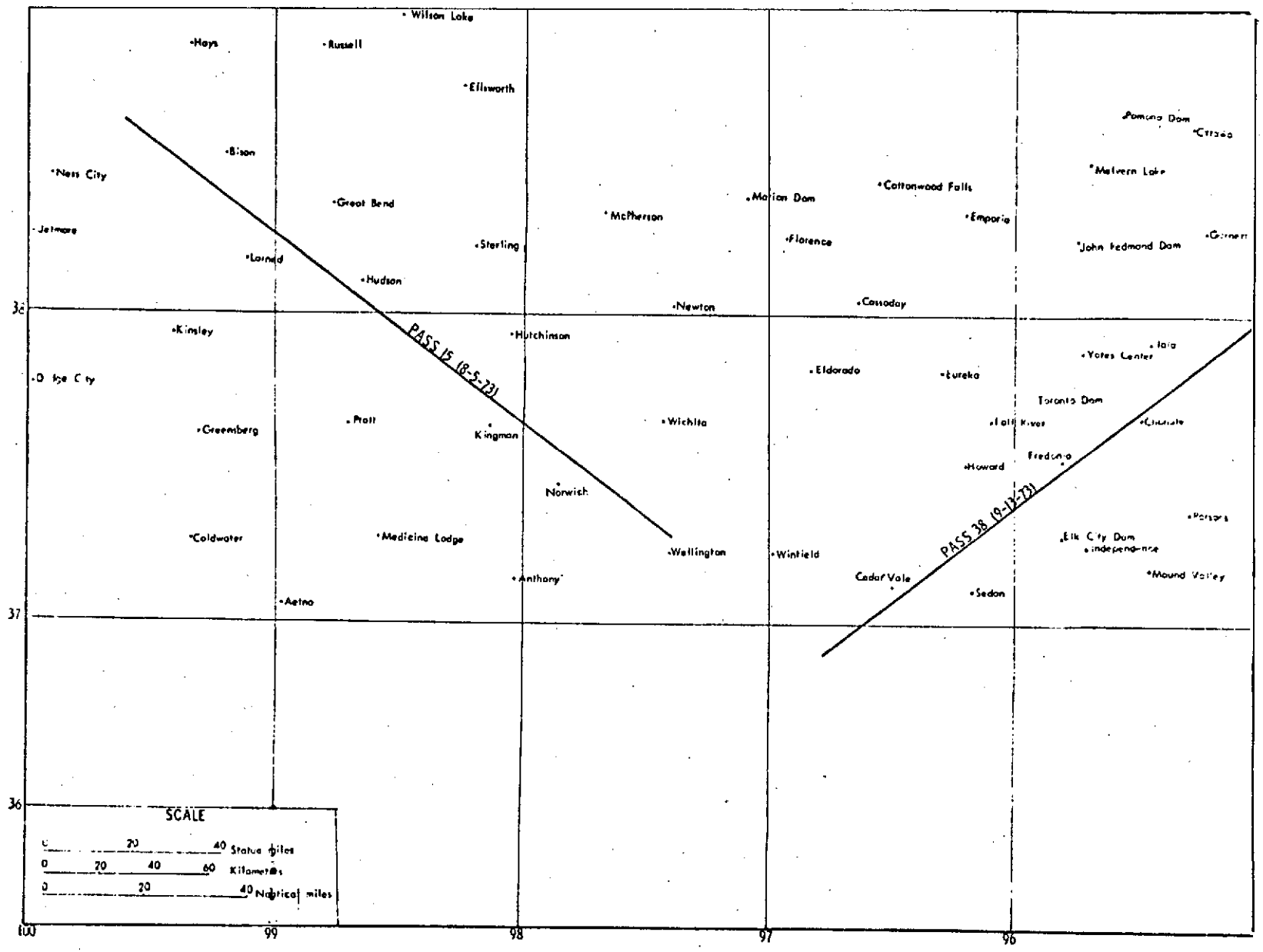

Wilson Lake
Hays
Russell
Ellsworth
Ness City
Bison
Great Bend
McPherson
Marion Dam
Cottonwood Falls
Emporia
Pomona Dam
Melvern Lake
John Redmond Dam
Jetmore
Larned
Sterling
Florence
Hudson
Newton
Cassoday
Kinsley
Hutchinson
PASS 15 (8-5-73)
Yates Center
Eldorado
Eureka
Toronto Dam
Greensburg
Pratt
Kingman
Wichita
Howard
Fredonia
Norwich
Coldwater
Medicine Lodge
Wellington
Winfield
Anthony
Cedar Vale
Sedan
Elk City Dam
Independence
Mound Valley
Aetna
PASS 38 (9-12-73)
SCALE
0 20 40 Statute miles
0 20 40 60 Kilometers
0 20 40 Nautical miles
100
99
98
97
96
37
36

Figure 2

available. It was assumed that the moisture profile at the calculated sites was the same as that at the nearest measured site.

The measured and computed values of soil water content in the upper six inches of soil depth were compared for the stations which had soil moisture measurements as well as meteorological data for calculations, Figure 3. The correlation coefficient is 0.87 and the averages of the measured and computed soil water are 9.50% and 9.36% respectively. Therefore, it appears that this is a useful technique for obtaining more complete coverage of ground truth information for each test site and also for adjusting all moisture measurements to the exact time of Skylab data collection.

In pass 5, Skylab flew over the test site from 2:00:30 pm to 2:02:00pm, local time. The soil samples were taken from 8:30 am, June 5, to 12:30 pm, June 6, 1973. There was no rainfall after Skylab passed this area or before the soil samples were taken. The soil water content of the first inch of soil depth in percentage by weight is plotted in Figure 4 for the 66 sites where soil moisture was measured and for the additional 48 stations where soil moisture was calculated. The technique of the weighted linear trend surface, which is based on distance for weight and a least squares solution for each grid intersection, was used to obtain

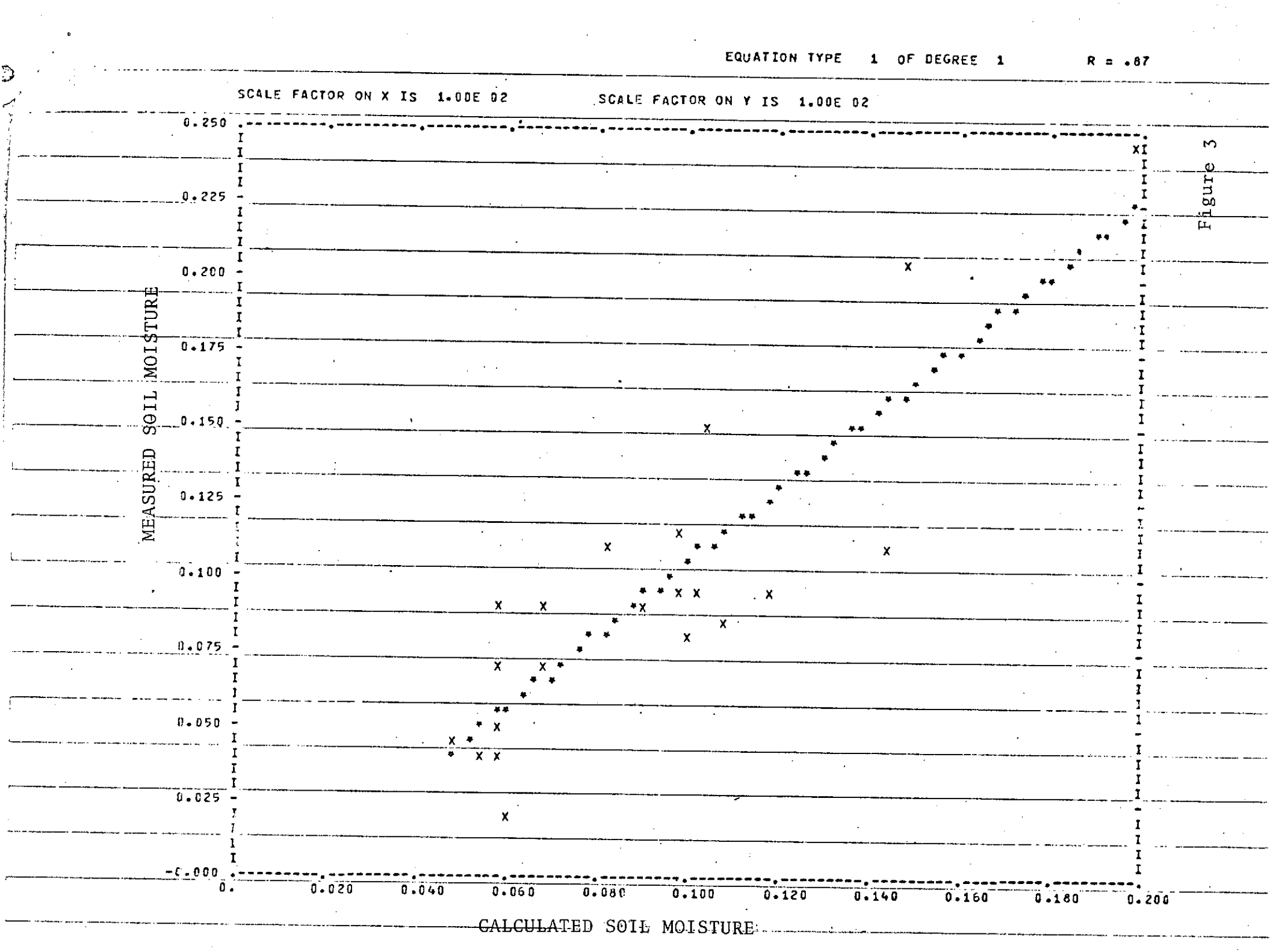
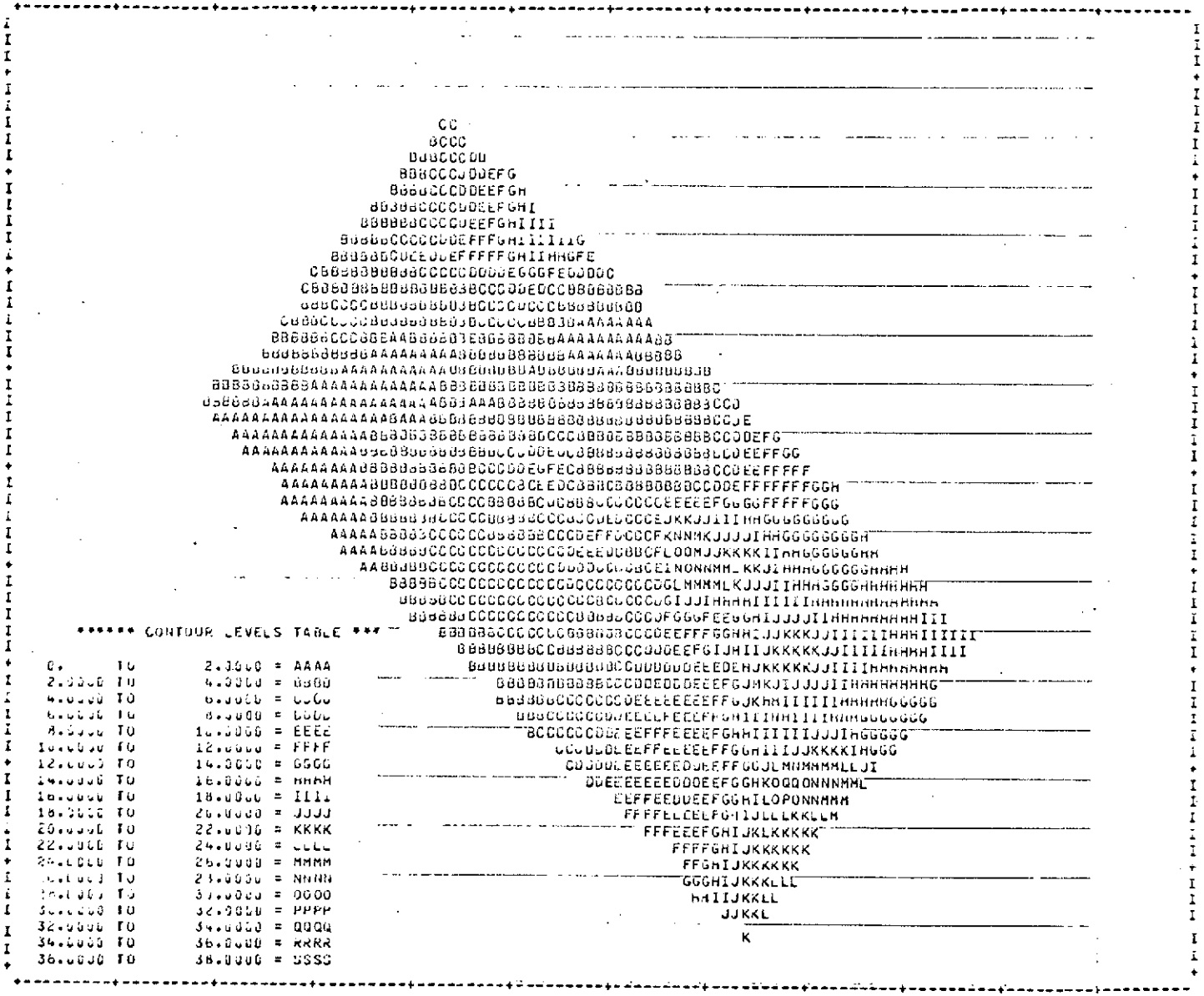

EQUATION TYPE 1 OF DEGREE 1 R = .87
SCALE FACTOR ON X IS 1.00E 02
SCALE FACTOR ON Y IS 1.00E 02
MEASURED SOIL MOISTURE
0.250
0.225
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
-0.000
0.
0.020
0.040
0.060
0.080
0.100
0.120
0.140
0.160
0.180
0.200
CALCULATED SOIL MOISTURE

Figure 3

****** MAP STRIP 1 ******



****** CONTOUR LEVELS TABLE ***

0.	TO	2.0000	= AAAA
2.0000	TO	4.0000	= BBBB
4.0000	TO	6.0000	= CCCC
6.0000	TO	8.0000	= DDDD
8.0000	TO	10.0000	= EEEE
10.0000	TO	12.0000	= FFFF
12.0000	TO	14.0000	= GGGG
14.0000	TO	16.0000	= HHHH
16.0000	TO	18.0000	= IIII
18.0000	TO	20.0000	= JJJJ
20.0000	TO	22.0000	= KKKK
22.0000	TO	24.0000	= LLLL
24.0000	TO	26.0000	= MMMM
26.0000	TO	28.0000	= NNNN
28.0000	TO	30.0000	= OOOO
30.0000	TO	32.0000	= PPPP
32.0000	TO	34.0000	= QQQQ
34.0000	TO	36.0000	= RRRR
36.0000	TO	38.0000	= SSSS

Figure 4

the distribution of soil moisture content for the entire test site.

In pass 16, Skylab passed over the test site from 10:04:00 am to 10:05:30 am, local time. The 720 soil samples from 120 locations were taken from 8:30 am, August 7, to 12:30 pm, August 9, 1971. There was 0.04 to 0.08 inches of rainfall in the early morning of August 8 in the northwest part of the test site. According to the water balance calculations and the distribution of rainfall, 3% to 6% of soil water content has been added to the first inch of 18 soil samples which were taken from Tahoka to Lubbock in the evening of August 7. The soil water content of the first inch of soil depth in percentage by weight was then calculated for the entire site based on the 120 soil moisture measurement locations and 48 additional locations where the soil moisture was calculated. Thus, a map of the distribution of soil moisture was obtained in the same way as for Figure 4.

In pass 38, Skylab passed over the test site of Texas from 11:57:00 am to 11:58:30 am, local time. The soil samples were taken from 8:30 am, September 8 to 12:00 pm, September 10. There were different amounts of rainfall and evapotranspiration in the different locations within the test site in the period from September 8 to September 13. It was necessary to adjust the water

content as measured by the soil samples for comparison with the data from the Skylab sensors. The water content of the soil samples was adjusted according to the calculated actual evapotranspiration and precipitation based on data from the nearest weather stations. The distribution of soil moisture content over the entire site was then calculated based on the 86 locations where soil moisture content was measured and the 35 stations where the soil moisture content was calculated. These additions and refinements should improve the quality of the ground truth information so that future correlations with Skylab sensors will be more precise.

In pass 15, Skylab passed over the Kansas test site from 10:37:10 am to 10:38:10 am, local time. The soil samples were taken from 8:30 am, August 5 to 12:00 pm, August 6. There was no rainfall after Skylab passed this site or before soil samples were taken. The water content of soil was so low that the actual evapotranspiration rate was negligible in the period of August 5 to August 6. The ground truth data for this pass included 42 soil sites where the moisture content was measured and 36 stations where calculations were completed for obtaining the soil moisture distribution patterns over the whole test site.

Correlations with the Skylab sensors have not been completed with these improved ground truth data but it is anticipated that the results will be improved over that previously reported.

References

Eagleman, Joe R., 1971. "An Experimentally Derived Model for Actual Evapotranspiration.. Agricultural Meteorology, 8, pp. 385-394.

Lin, Wen C. and Joe R. Eagleman, 1971. "Evaporation, Evapotranspiration and Water Balance at Lawrence, Kansas", Paper presented at The First Conference on Biometeorology and Tenth Conference on Agricultural Meteorology, June 9-11, 1971, Columbia, Missouri.

Penman, H.L., 1956. "Evaporation, an Introductory Survey", Neth. J. Agr. Sci., 4, pp 9-29.

Salter, P.J. and J.B. Williams, 1965. "The Influence of Texture on the Moisture Characteristics of Soils; II. Available-water Capacity and Moisture Release Characteristics", Journal of Soil Science, 16(2), pp 310-317.

Thornthwaite, C.W., 1948. "An approach Toward A Rational Classification of Climate", Geog.Review, 38, pp 55-94.

Thornthwaite, C.W. and Mather, J.R., 19-55."The Water Budget and its Use in Irrigation", In U.S. Dept. of Agriculture Yearbook, pp 346-358.

Thornthwaite, C.W. and Mather, J.R., 1957, "Instructions and Tables for Computing Potential Evapotranspiration and Water Balance", Publications in Climatology, 10 (3), pp185-311.